WFIRST Update

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ASTROPHYSICS

Decadal Survey Missions

LRD: 2019

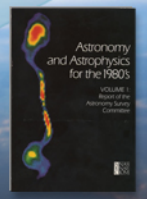
LRD: 2020s

2003

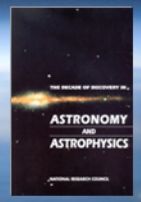
1999

1990

1972 Decadal Survey *Hubble*



1982 Decadal Survey *Chandra*



1991 Decadal Survey *Spitzer*

2001 Decadal Survey *JWST, SOFIA*

2010 Decadal Survey *WFIRST*

Guidance from NWNH

WFIRST
WIDE-FIELD INFRARED SURVEY TELESCOPE
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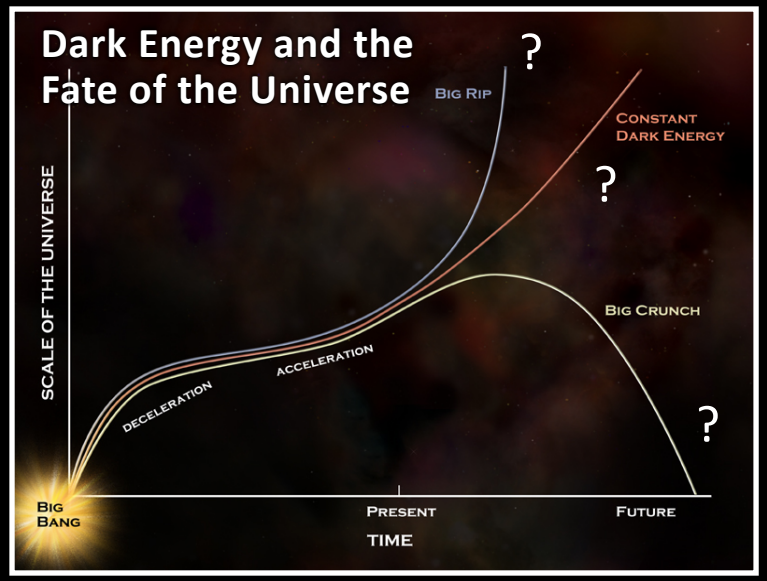
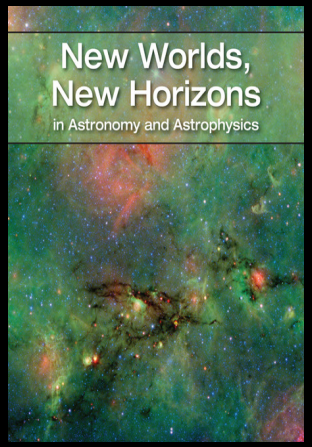
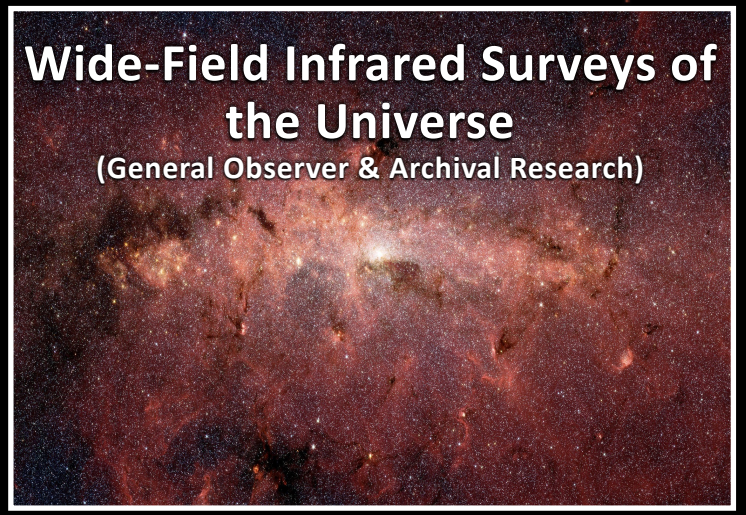
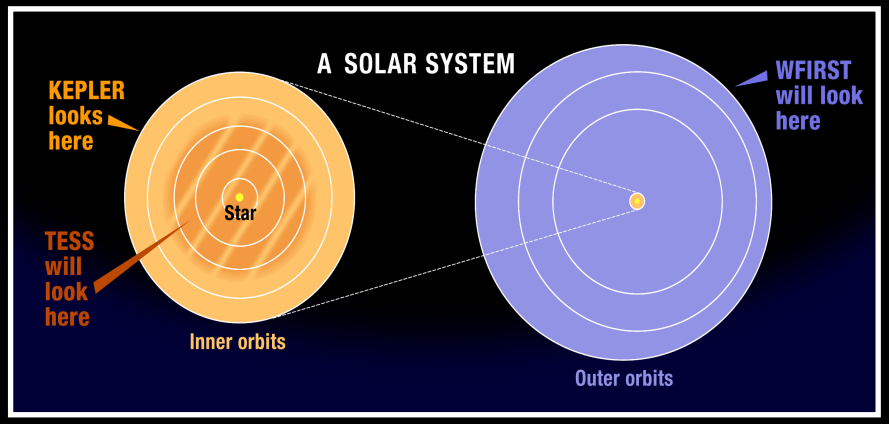






The full distribution of planets around stars



Science Goals

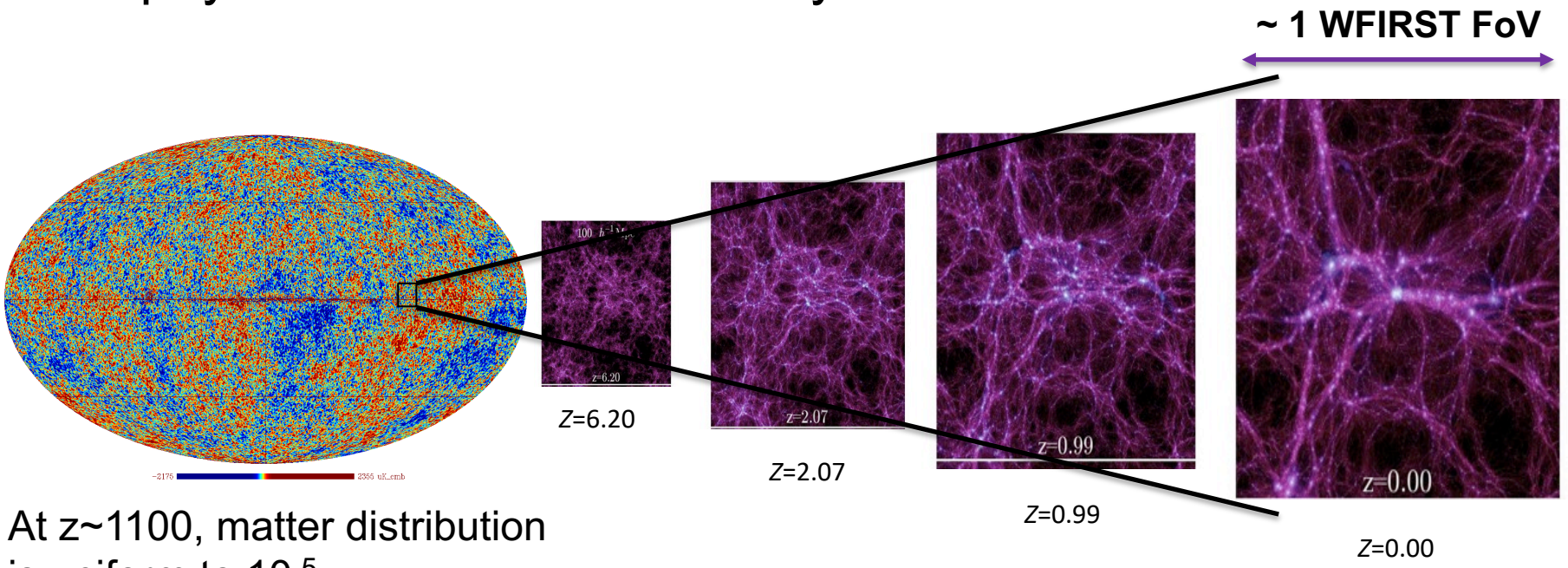
- **Produce Hubble quality infrared sky images and spectra over 1000's of square degrees of sky**
- **Determine the expansion history of the Universe and the growth history of its largest structures in order to test possible explanations of its apparent accelerating expansion including Dark Energy and modifications to Einstein's gravity.**
- **Complete the statistical census of planetary systems in the Galaxy, from the outer habitable zone to free floating planets**
- **Demonstrate new technologies enabling direct imaging & spectroscopy of giant planets and debris disks from habitable zones to beyond the ice lines and characterize their physical properties.**
- **Provide a robust guest observer program utilizing a minimum of 25% of the time over the 5 year baseline mission and 100% in following years.**
- **Provide a robust archival research program with access to all data from the mission.**

Wide FoV enables study of evolution of the Universe

WFIRST will measure expansion history *and* growth of structure

- If results discrepant -> breakdown of general relativity
- If results agree -> learn about nature of dark energy

WFIRST provides multiple probes, enabling cross-checks for astrophysical and instrumental systematics



At z~1100, matter distribution is uniform to 10^{-5}

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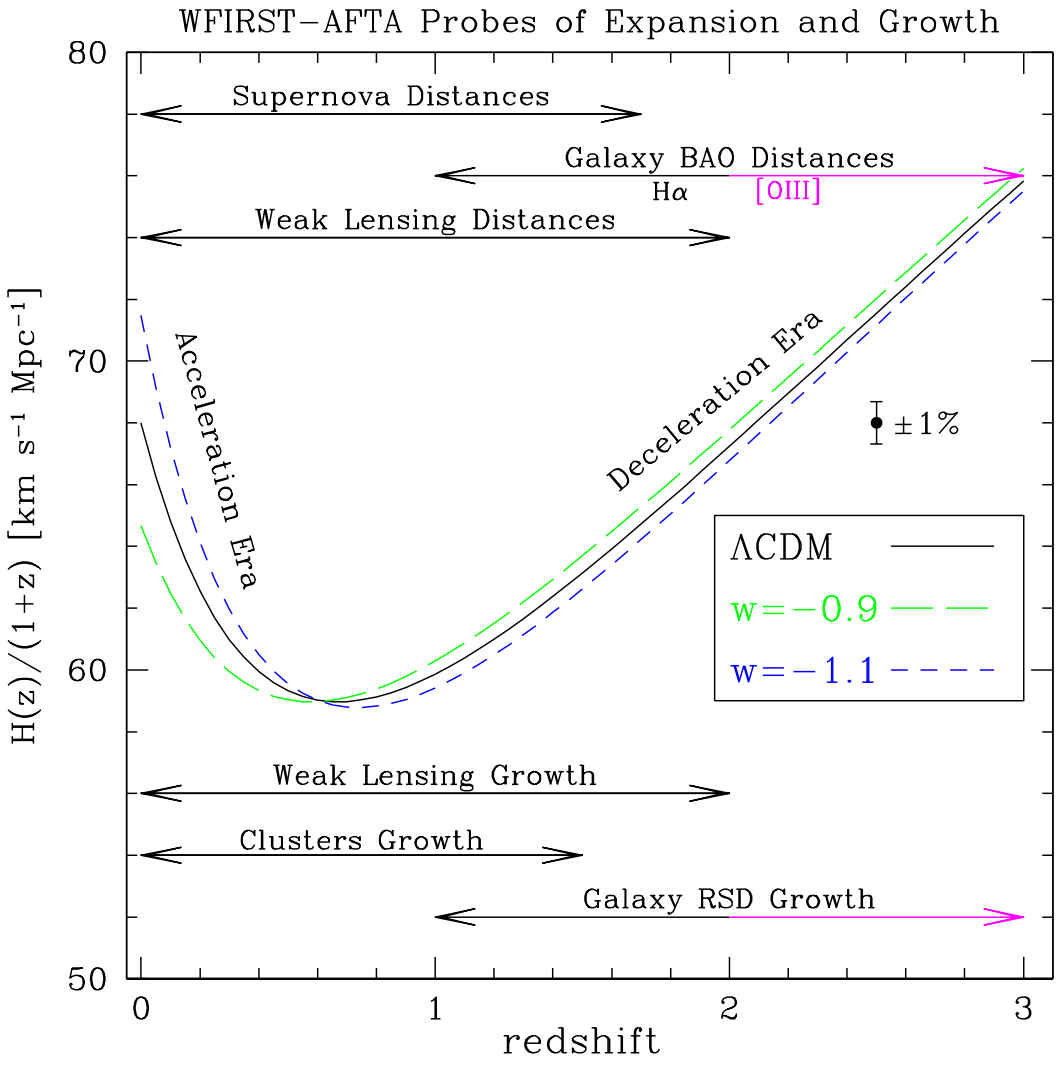
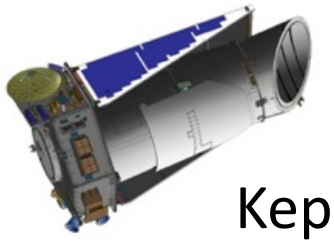
Premier Dark Energy Observatory

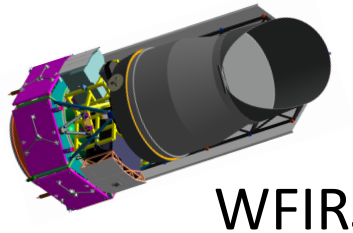
- WFIRST combines all techniques to determine the nature of Dark Energy.
- Only observatory doing such comprehensive observations
- High precision data will be optimally combined for the best measurement



Compete the Census of Exoplanets - Microlensing



Kepler



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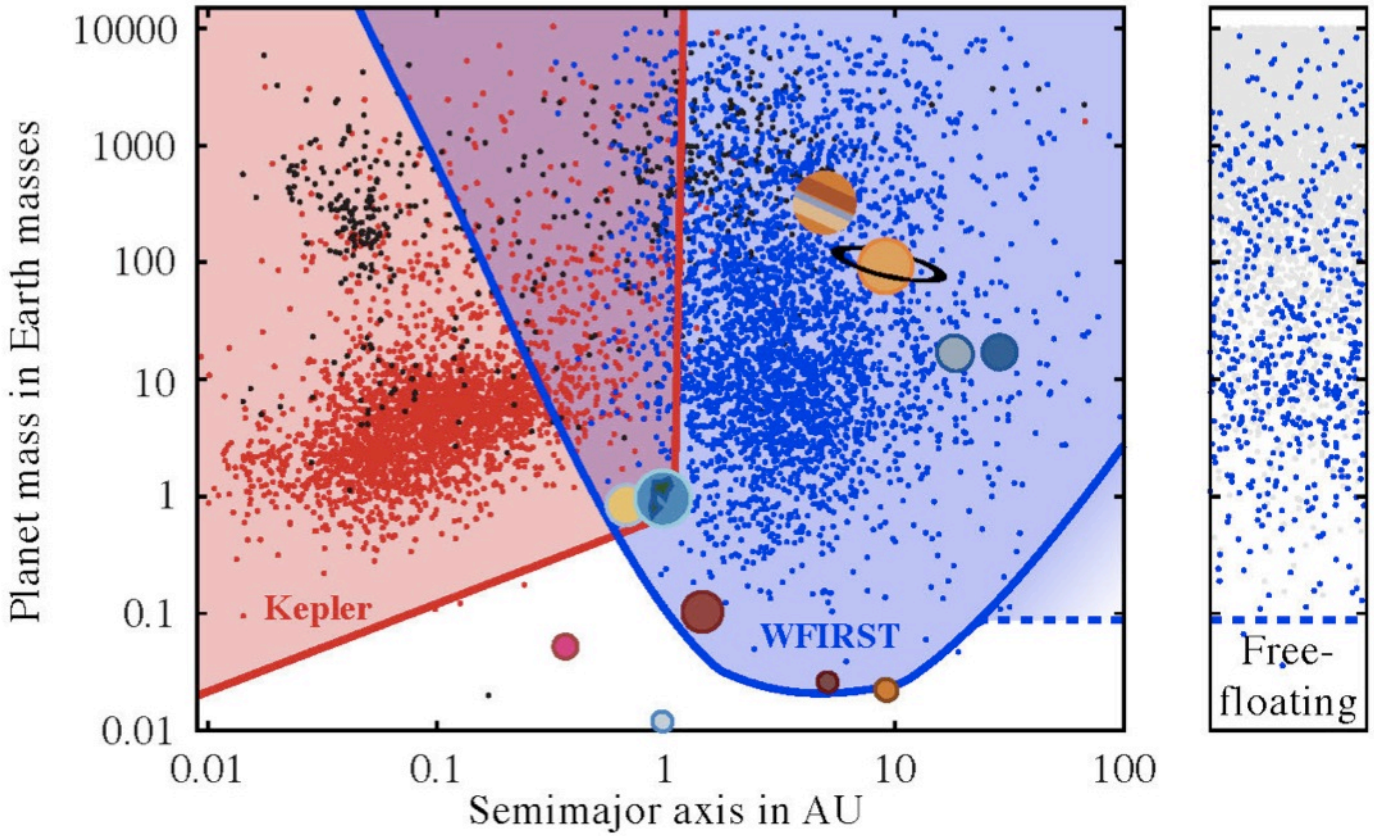

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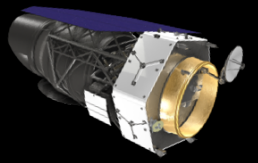
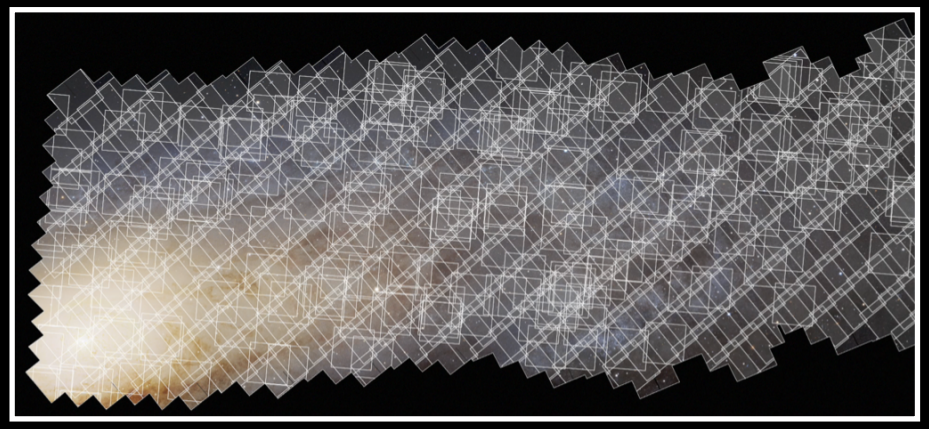
Sample GO Program
Assembly of Galaxies

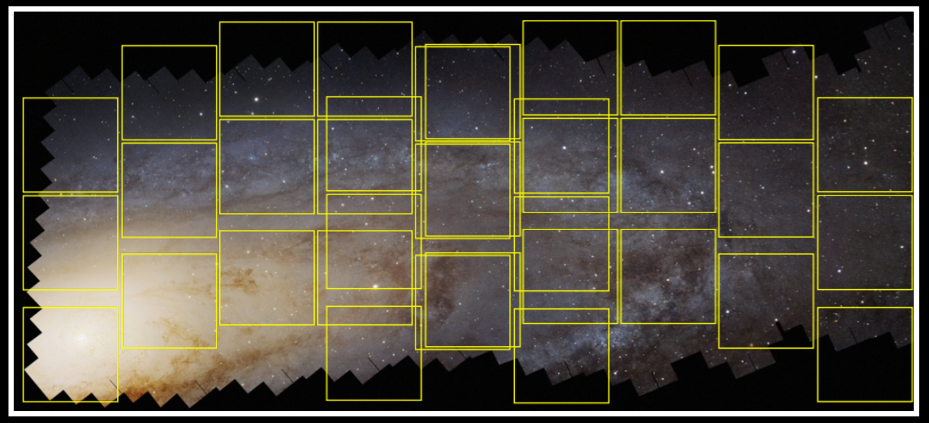
Andromeda - PHAT Survey

The Hubble Way
(400+ individual pointings)

The WFIRST Way
(2 pointings)







WFIRST will survey nearby galaxies 100x faster than Hubble

Pioneering High Contrast Coronagraph as Technology Pathfinder

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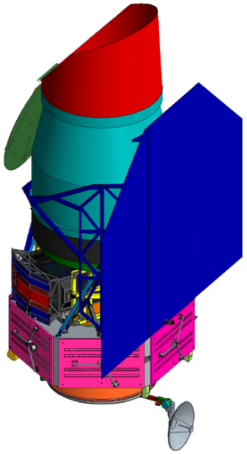
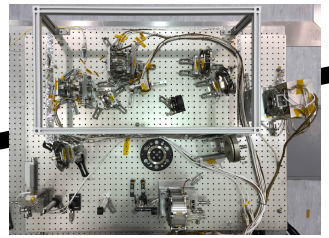
NASA

Large Ultra-stable Space Telescope & Observatory

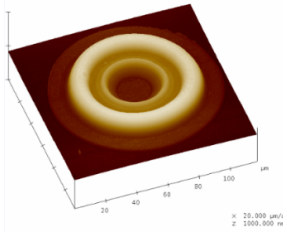


Autonomous Ultra-Precise Wavefront Sensing & Control System



First Use of Deformable Mirrors in Space

High Contrast Coronagraph Masks



Ultra-low Noise Photon Counting Visible Detectors

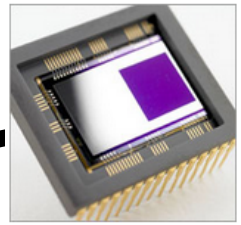
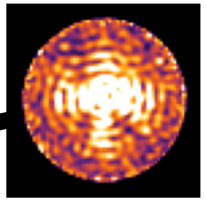
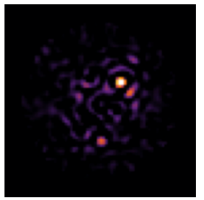


Image Processing at Unprecedented Contrast Levels



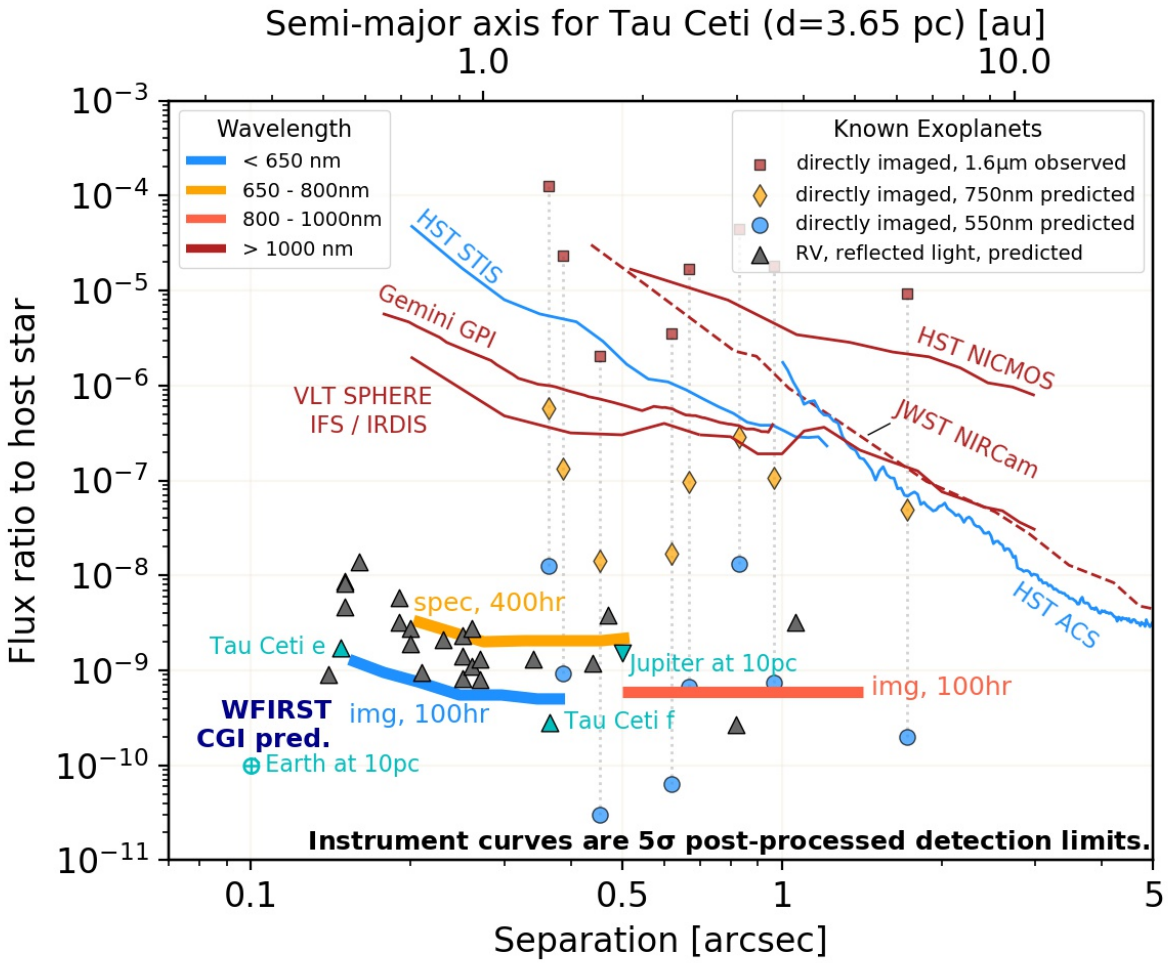


WFIRST CGI is a direct predecessor to potential future flagship direct imaging missions aimed at Earth-like exoplanets (HabEx & LUVOIR)

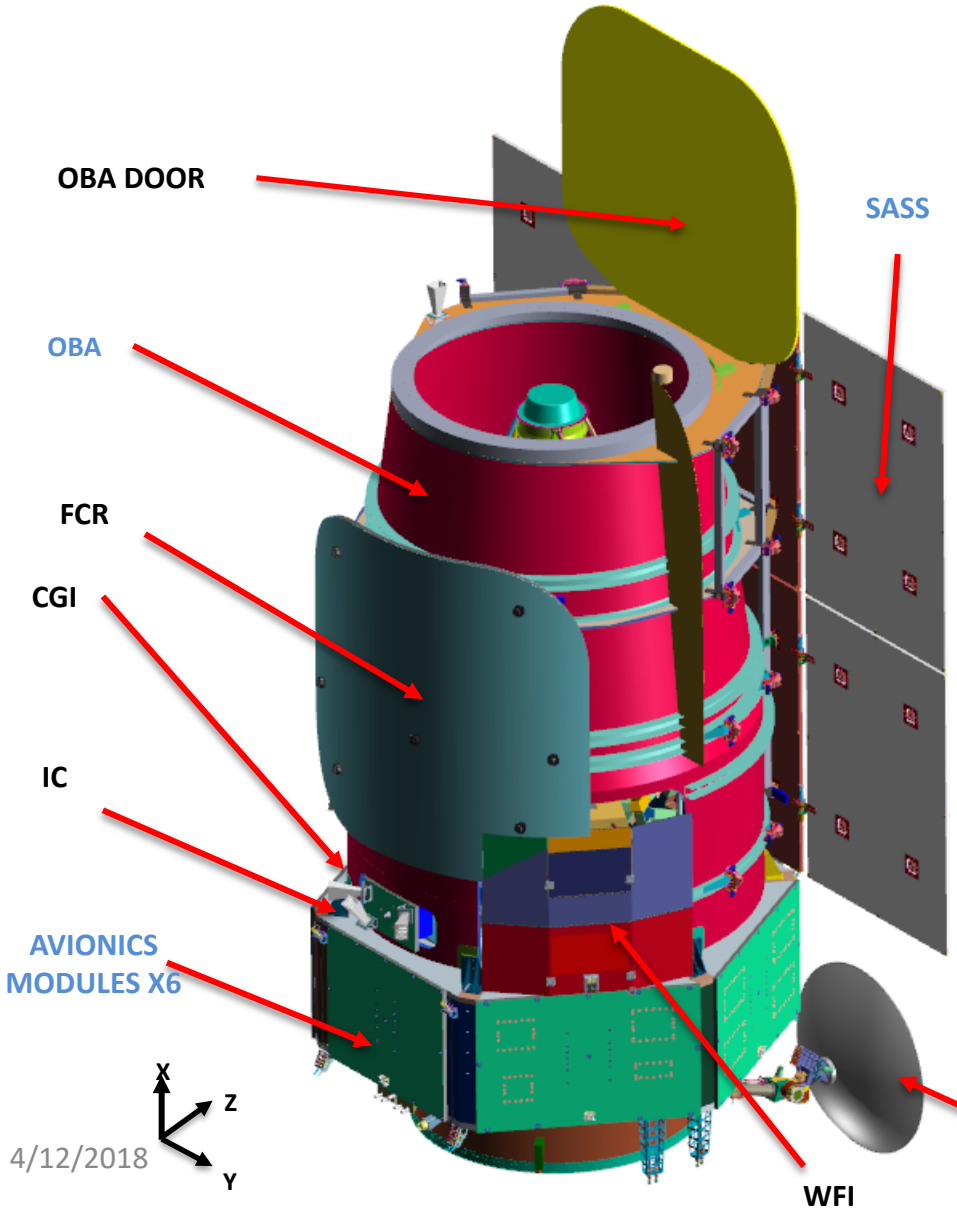
WFIRST Brings Humanity Closer to Characterizing exo-Earths

If present performance predictions are realized, there is potential for:

- 1000-fold improvement over present capabilities.
- Dozens of planets within reach of characterization
- Detection limit can reach super-Earths



WFIRST Observatory Concept



Key Features

Telescope: 2.4m aperture

Instruments:

- Wide Field Imager / Spectrometer & Integral Field Unit
- Internal Coronagraph with Integral Field Spectrometer

Data Downlink: 275 Mbps

Data Volume: 11 Tb/day

Orbit: Sun-Earth L2

Launch Vehicle: 4 options

Mission Duration: 5 yr, 10yr goal

Serviceability: Observatory designed to be robotically serviceable

Starshade compatible

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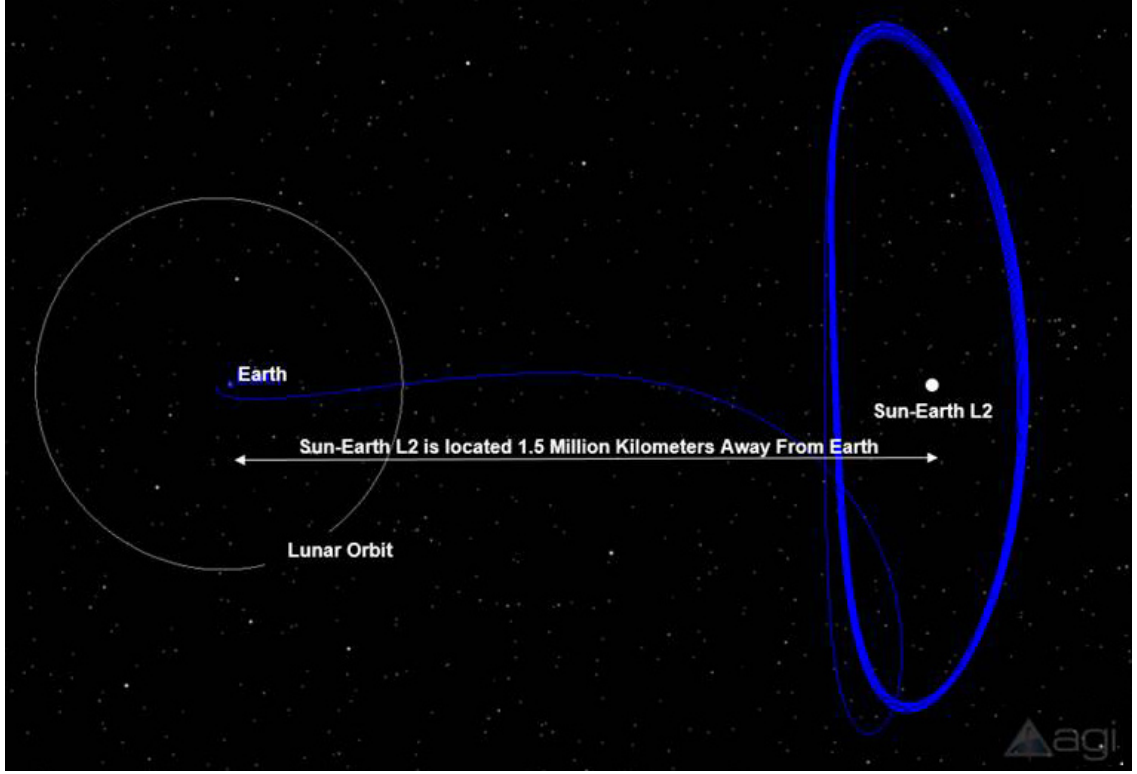
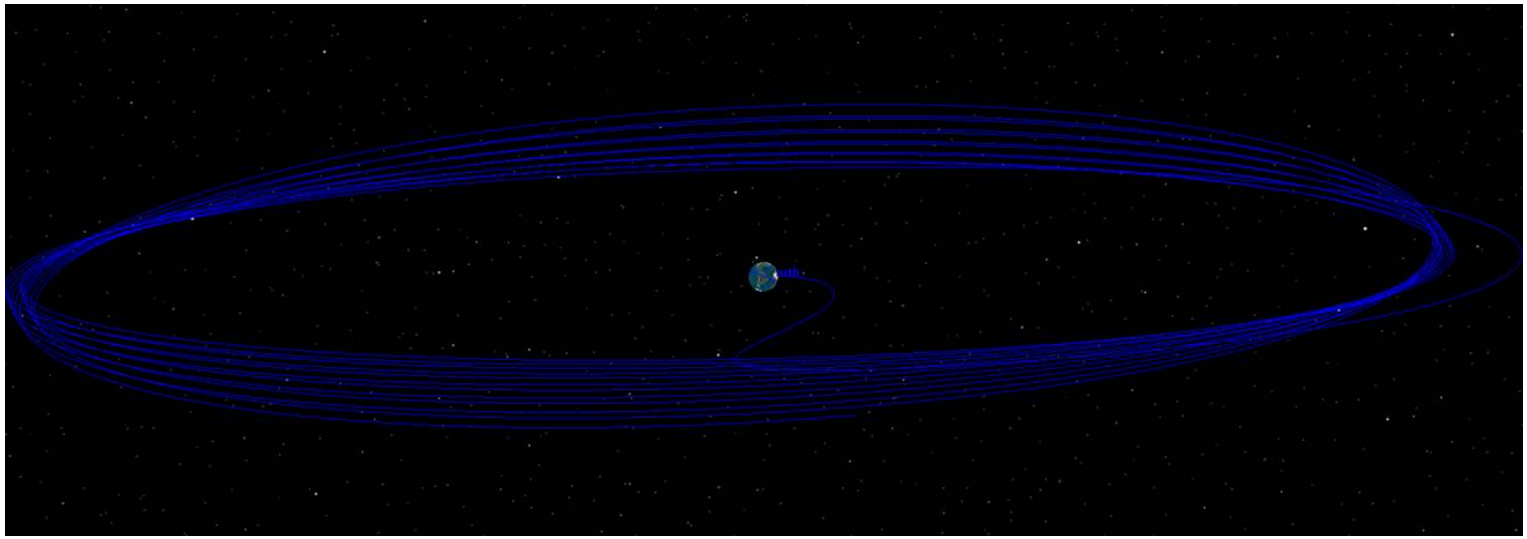




Project Status

- System Requirements Review / Mission Definition Review held February 27 – March 1
  - Do we have the right requirements? / Does the mission design meet those requirements?
- KDP-B scheduled for May 22, 2018
- Notional schedule:
  - PDR: late 2019
  - CDR: mid 2021
  - Launch: 3rd quarter 2025

WIETR Timeline

WFIRST Independent External Technical/Management/Cost Review

- June-July 2017: Initial activities
  - Delivery of documents for review
- August 2017: Site visits
- October 2017: report released; new SMD direction to project
- December 2017: finalize revised baseline
- January 2018: began delivering materials to Standing Review Board for System Requirements Review / Mission Definition Review

SMD direction 10/19/2017

I am directing the Goddard Space Flight Center to study modifying the current WFIRST design, the design that was reviewed by the WIETR, to reduce cost and complexity sufficient to have a cost estimate consistent with the $3.2B cost target set at the beginning of Phase A.

The following constraints and changes are directed to begin this design modification study:

- *The basic architecture of the mission, including the use of the existing 2.4m telescope, a widefield instrument, and a coronagraph instrument, shall be retained.*
- *The implementation of the mission risk classification shall be consistent with the findings of the WIETR report.*
- *Reductions shall be taken in the widefield instrument.*
- *The coronagraph instrument shall be treated as a technology demonstration instrument, consistent with the findings of the WIETR report; in addition, reductions shall be taken in the coronagraph instrument.*
- *The cost of science investigations shall be reduced.*
- *The additional use of commercial subsystems and components shall be considered for the spacecraft; however, serviceability for both the spacecraft and the payload will be retained.*

Cost status

- Project baseline was revised to fit in $3.2B
- Savings that don't affect science return:
  - Incorporate international contributions
  - Improved budget profile
  - STMD contributions towards coronagraph
  - Optimization of design, integration & test flow
    - Eliminated one processor by combining functions
    - Simplifications to payload I&T saves schedule and reduces some test equipment & facility costs
  - -> Combination of the above saves 6 months in schedule

Unchanged aspects of architecture

- Aspects of mission architecture that remain unchanged, as directed:
  - Existing 2.4m telescope components
  - Wide-Field Instrument
  - Coronagraph Instrument
  - Serviceability of spacecraft and payload
  - Starshade compatibility

Risk Classification

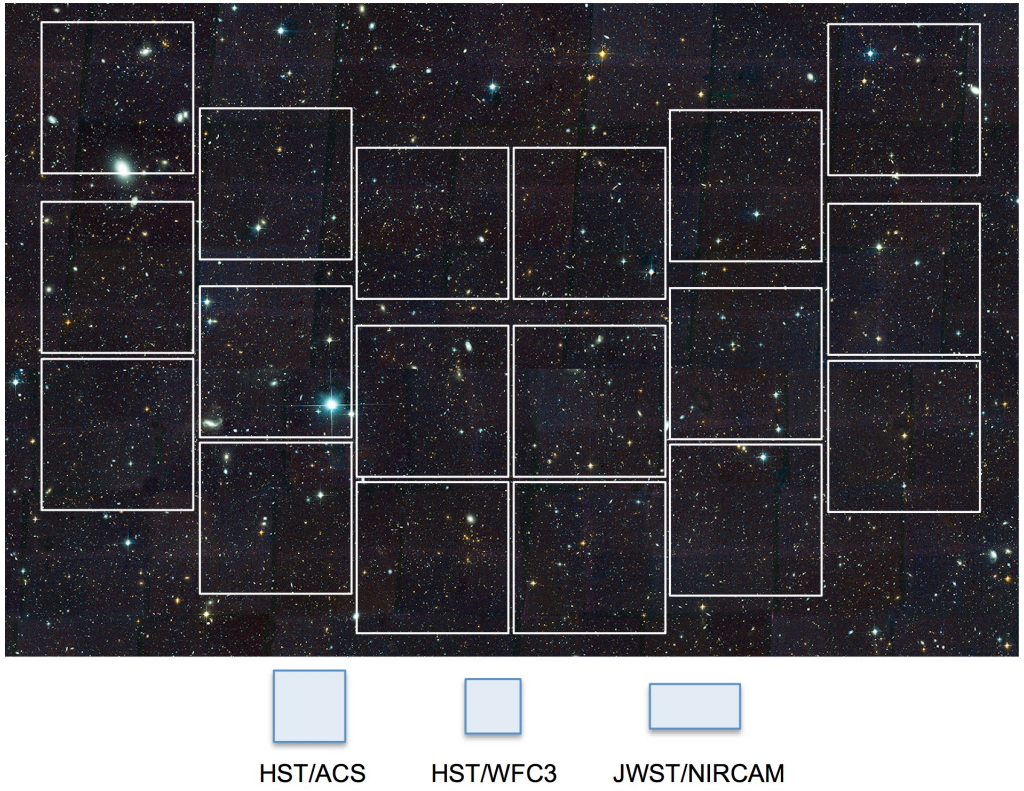
- Class A will be implemented with the following tailoring:
  - In general, a protoflight approach is used for qualification. Engineering units are used for new or modified hardware.
  - For WFIRST-unique developments, sparing is at the subassembly level with additional kitted spares; for procured components, no spares are planned.
  - Comply with Class A requirement for Level 1 parts except where additional screening adds little value or invalidates heritage of procured components
  - Coronagraph is Class C with tailoring to be determined during Phase B

Wide-Field Instrument

- Modified detector requirements to specify performance at the focal plane level, rather than at the individual detector level
  - Quality across entire focal plane is key discriminator for WFI science
  - New requirements increase yield, i.e. decrease time required to manufacture full set of flight detectors
- Decreased focal plane operating temperature from 100K to 95K
  - Reduces noise, thereby increasing detector yield
  - Colder temperature is possible by utilizing WFI radiator thermal margin
- Assume the Integral Field Channel (IFC) is contributed by an international partner.
- Main simplification to WFI, elimination of cryocooler, was made prior to WIETR.
- *Otherwise maintained full WFI H/W capabilities*

Wide-Field Instrument

WFIRST Field of View



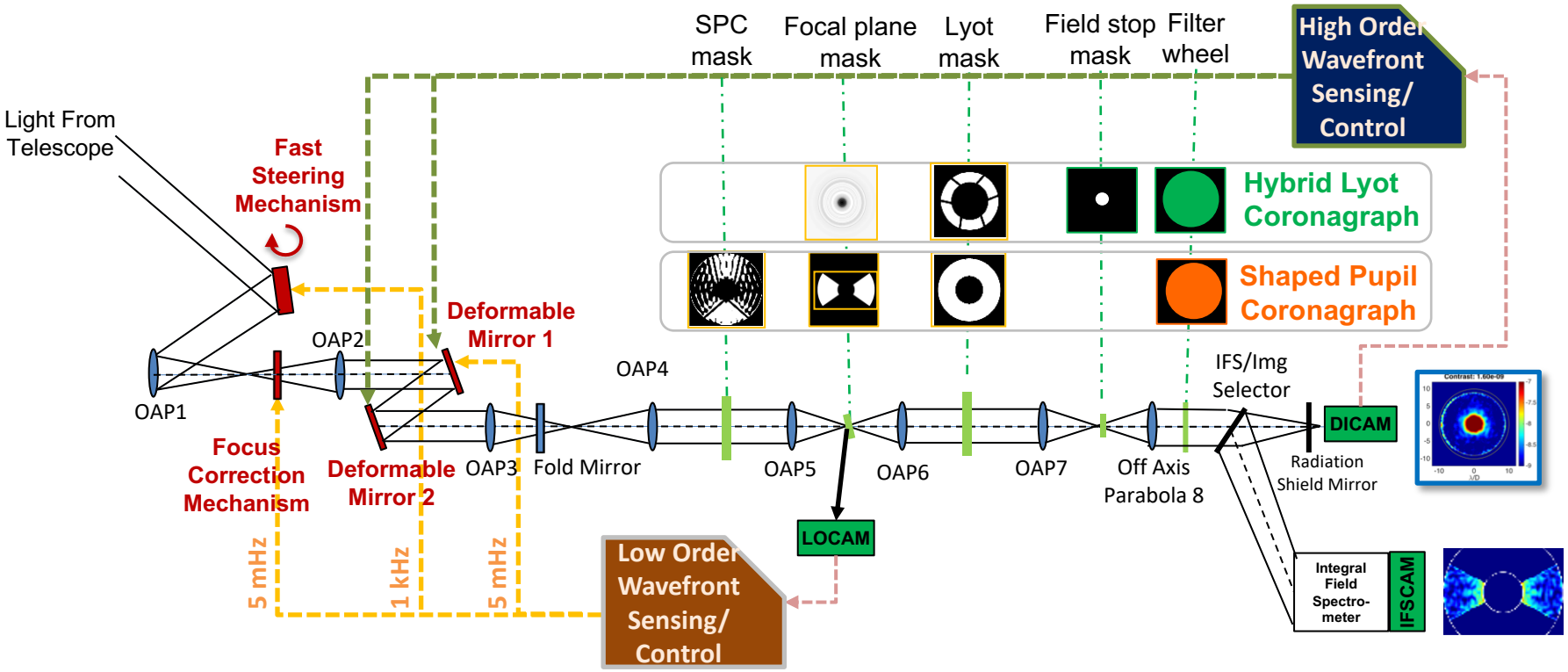
Diffraction-limited imaging
0.28 square degree FoV
0.11” pixels
R~4 filters spanning 0.48-2.0 μm
Sensitivity: 27.8 H(AB) @5σ in 1hr

Slitless grism:
1.0-1.93 μm
R: 435-865

Coronagraph

- Coronagraph is now treated fully as a technology demonstration instrument.
  - Reduction in masks & filters shortens I&T flow
  - Change to participating scientist program eliminates most associated science operation center costs
    - Model similar to PI-class instrument
  - Retained Class C designation with tailoring to be determined during Phase B
  - *Otherwise maintained CGI architecture & functions*

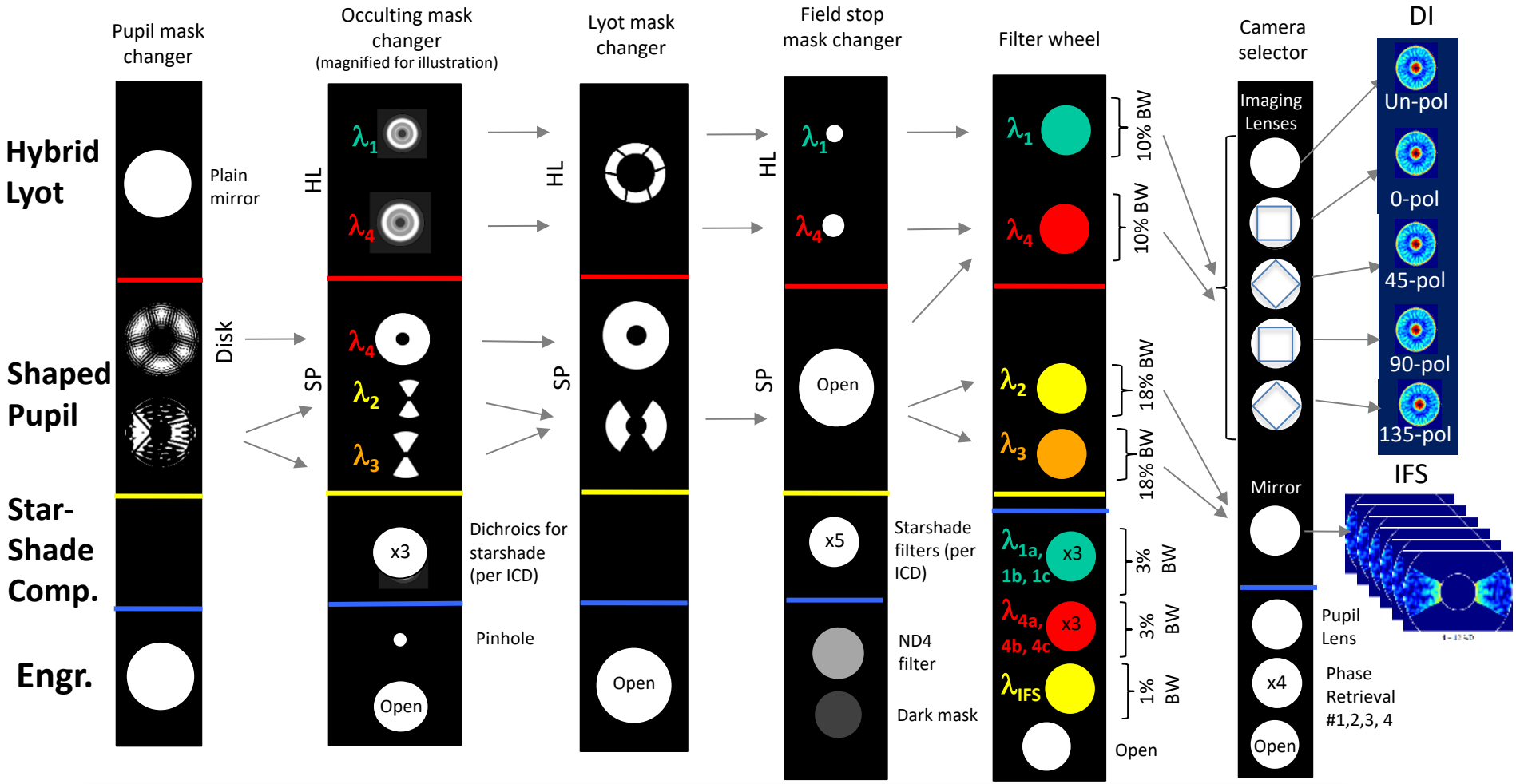
Coronagraph architecture



Basic architecture unchanged.

Some modes removed and some not tested to reduce cost.

CGI Configuration



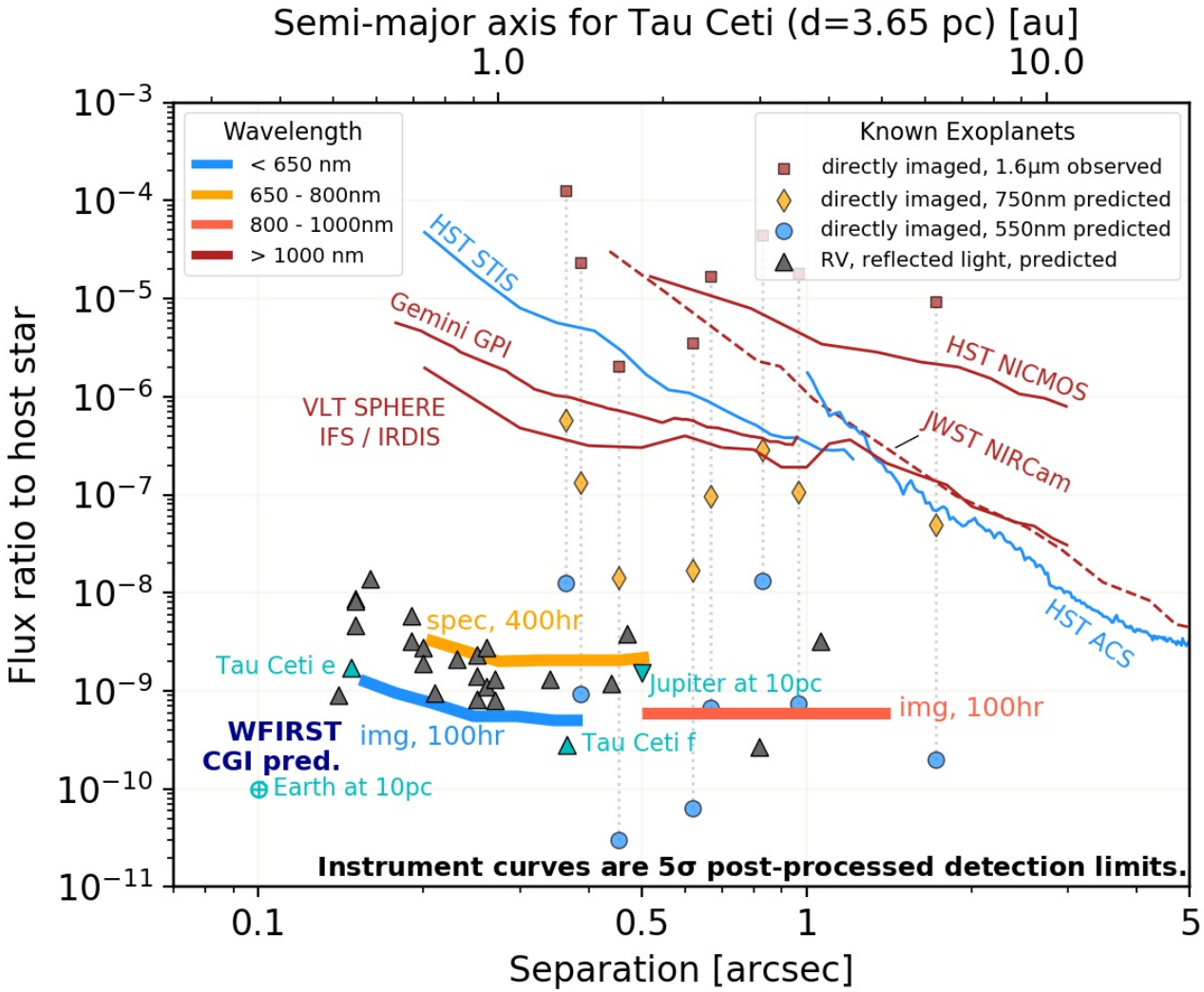
λ_1=575 nm, 10% (annular, 3-9 λ/D)

λ_2=660 nm, 18% (bow-tie / IFS, 3-9 λ/D)

λ_3=760 nm, 18% (bow-tie / IFS, 3-9 λ/D)

λ_4=825 nm, 10% (annular, 3-19 λ/D)

CGI current performance predictions



Science investigations

- 10% cut across the board for future science team funding
- GO modified to provide only modes required by the other surveys, and limited to three calls
  - Still have 5 archival research calls
- Significant reduction to wide-field science operations center capability: Deleted PSF database & tools, simulated source injection, and ability of pipeline to process fully simulated data
- Consolidated science center activities at STScI. Microlensing, CGI PSP support, and GO Program remain at IPAC.

Science Investigations

- What has not changed:
  - All observing time to be selected competitively
    - Some close to launch, the rest periodically thereafter
  - All data will be public immediately
  - Scientific priorities to be updated throughout mission, based on landscape at the time
- Changes under consideration:
  - Models for time allocation to large programs
  - Models for structure of teams for large programs
  - Have begun consultations w/FSWG and will be seeking community input on both topics

Near-Term Activities

- Execute the Project Plan presented at SRR/MDR
- Complete the element SRRs in coming months
  - Spacecraft, telescope, instruments, ground system
- Complete negotiations with international partners
- Respond within 60 days to the language in the FY18 Consolidated Appropriations Act
- Flow requirements to lower levels; complete optimization of instrument design parameters

BACKUP

Key WIETR Findings

- **The WFIRST planned science surveys program and system design offer groundbreaking and unprecedented survey capabilities to the Dark Energy, Exoplanets, and Astrophysics communities.**
- The WFIRST team has done a considerable amount of work for a project that has yet to enter KDP-B, particularly in areas that minimize development and cost risk; key processes for execution and control are in place, and **the science and mission system concepts are mature**.
- The WFIRST Project and Subsystem Management, Science, Systems Engineering, and Business Management personnel are very experienced, including in the management of large/flagship missions, and have the necessary skills to lead a mission of the level of complexity of WFIRST.
- **The WFIRST Project has been methodical, thorough, and inclusive in the analysis and derivation of the science and corresponding technical and data requirements**, however, additional work is needed to: 1) negotiate and codify them clearly and unambiguously, 2) include Programmatic Direction that should be codified as Level 1 requirements; and 3) develop a plan to comprehensively validate them.
- **The Wide-Field Instrument (WFI) is the primary instrument of WFIRST; a tremendous science capability that will be substantially more capable than Euclid, far better than HST or JWST, and well beyond what is possible from the ground in the conduct of faint infrared surveys that remain of high science interest**.

Commercial Subsystems

- The Project conducted formal make/buy trade studies for spacecraft components with the greatest potential for commercialization.
  - Most components/subsystems procured from industry
  - Many “in-house” subsystems designed in-house but fabricated by industry